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HOST-SPECIFIC DEMOGRAPHIC STUDIES OF WILD *BACTROCERA TAU* (WALKER) (DIPTERA: TEPHRITIDAE)

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Abstract.—Developmental time and survival rates of preadult stages and adult survival and fecundity of *Bactrocera tau* (Walker) were examined when reared on six common hosts at 25° C. The durations of the egg and pupal stages were independent of host. The larval developmental time ranged from 4.5 days, for those reared on cucumber, to 7.3 days, for those reared on eggplant. The survival rate of larvae ranged from 48%, when reared on bitter melon, to 77%, when reared on cucumber. Net reproductive rates (R_o) were similar when the files were reared on bitter melon, papaya, and cucumber, and they were twice that of flies reared on eggplant. The generation time ranged from 59.1 days, for flies reared on pumpkin, to 40.7 days, for those reared on eggplant. The intrinsic rate of increase ranged from 0.087, for the flies reared on watermelon, to 0.123, for those reared on cucumber. The data indicate that *B. tau* is capable of reaching high population densities quickly on a number of hosts, and that this fly poses a significant threat to agriculture in California.

Key Words.—Insecta, demography, reproductive parameters, life history traits, *Bactrocera tau*

Demographic studies of fruit flies (Diptera: Tephritidae) are important for developing of effective control programs, efficient mass rearing of sterile flies, and the interpretation of trap data (Carey 1993, Vargas & Carey 1990). Several economically important species including *Ceratitis capitata* (Weidemann) (Carey 1984, Vargas et al. 1984, Vargas & Carey 1990); *Bactrocera cucurbitae* (Coquillett) (Vargas et al. 1984, Carey et al. 1985, Vargas & Carey 1990); *Bactrocera dorsalis* (Hendel) (Vargas et al. 1984, Foote & Carey 1987, Vargas & Carey 1990); *Bactrocera* Malaysian A and B (Chua 1991a, b) and *Bactrocera latifrons* (Hendel) (Vargas & Nishida 1985) have been studied. Because larval host is an important factor determining fruit fly geographic distribution and abundance, many studies have investigated the effect of host plants on fruit fly demographic characters (Carey 1984, Krainacker et al. 1987, Celedonio-Hurtado et al. 1988, Yang et al. 1990).

Bactrocera tau (Walker), the pumpkin fly, is an economically important fruit fly distributed in South and Southeast Asia and some Pacific islands (Hardy 1973). It has a host range similar to that of *B. cucurbitae,* but is considered a more destructive species in southern China (Chao & Ming 1986). This study investigated *B. tau* host-specific, pre-adult survival and development; determined the age-specific fecundity of its adults, when reared on six different hosts; and analyzed the effect of host on its population growth.

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Table 1. Mean larval and pupal development times and survivorship for *Bactrocera tau* reared on seven hosts at 25° C.

Host	Larva		Pupa	
	$\bar{x}$ (± SD)[a]	% survival	$\bar{x}$ (± SD)	% survival
Bitter melon	5.2 (1.1)	48	9.2 (0.4)	94
Cucumber	4.5 (0.7)	77	9.6 (0.5)	99
Eggplant	7.3 (1.2)	56	9.4 (0.6)	91
Papaya	5.3 (0.8)	68	8.8 (0.5)	95
Pumpkin	6.2 (0.9)	59	9.2 (0.8)	92
Watermelon	5.3 (0.9)	75	9.3 (0.7)	96

[a] In days.

Materials and Methods

Bactrocera tau were reared from infested bitter melon (*Momordica charantia* L.) growing near the campus of Zhongshan (Sun Yat-sen) University, Guangzhou, China. The colony was reared in a room maintained at 25° ± 0.5° C, 50–75% RH, and 12:12 L:D. Pumpkin [*Cucurbita moschata* (Duchesne) Duchesne ex Poiret] was used as the larval host. After three generations, the offspring were used in the following experiments. All tests were replicated three times.

Duration and mortality of larval and pupal stages were evaluated as follows. A pumpkin slice was exposed to gravid females for one hour, after which the eggs were removed with a knife and placed on moist black cloth in a Petri dish. Fifty newly hatched larvae each were seeded on a piece of host, which was held in a 1 liter glass jar with a layer of sand; the hosts were: bitter melon [*Momordica charantia* L.], cucumber [*Cucumis sativus* L.], eggplant [*Solanum melonena* L.], papaya [*Carica papaya* L.], pumpkin [*Cucurbita moschata* (Duchesne) Duchesne ex Poiret], or watermelon [*Citrullus lanatus* (Thunberg) Matsumato & Nakai]. Larvae were checked daily and food was added as needed. As pupation occurred,

Table 2. Reproductive parameters (eggs per female), mean age of reproduction, and expectation of life (days) of adult *B. tau* reared on six different hosts.

Host	Gross rate[a]	Net rate[b]	Eggs per day	Mean age reproduction[c]	Expectation of life[d]
Bitter melon	1289	819	7.5	81.3	109
Cucumber	911	538	7.5	59.5	72
Eggplant	886	372	7.2	58.3	52
Papaya	1064	563	6.6	77.2	85
Pumpkin	1512	640	5.8	129.2	103
Watermelon	1700	554	7.4	105	75

[a] Gross fecundity rate is expressed as the number of eggs per female that lives to the last possible day of life.

[b] Net fecundity rate is expressed as the number of eggs per female, considering adult survival.

[c] Mean age of reproduction is the age, in days, at which an average female has laid half of the total number of eggs.

[d] Expectation of life is the average age of death expressed in days; calculated using data from males and females.

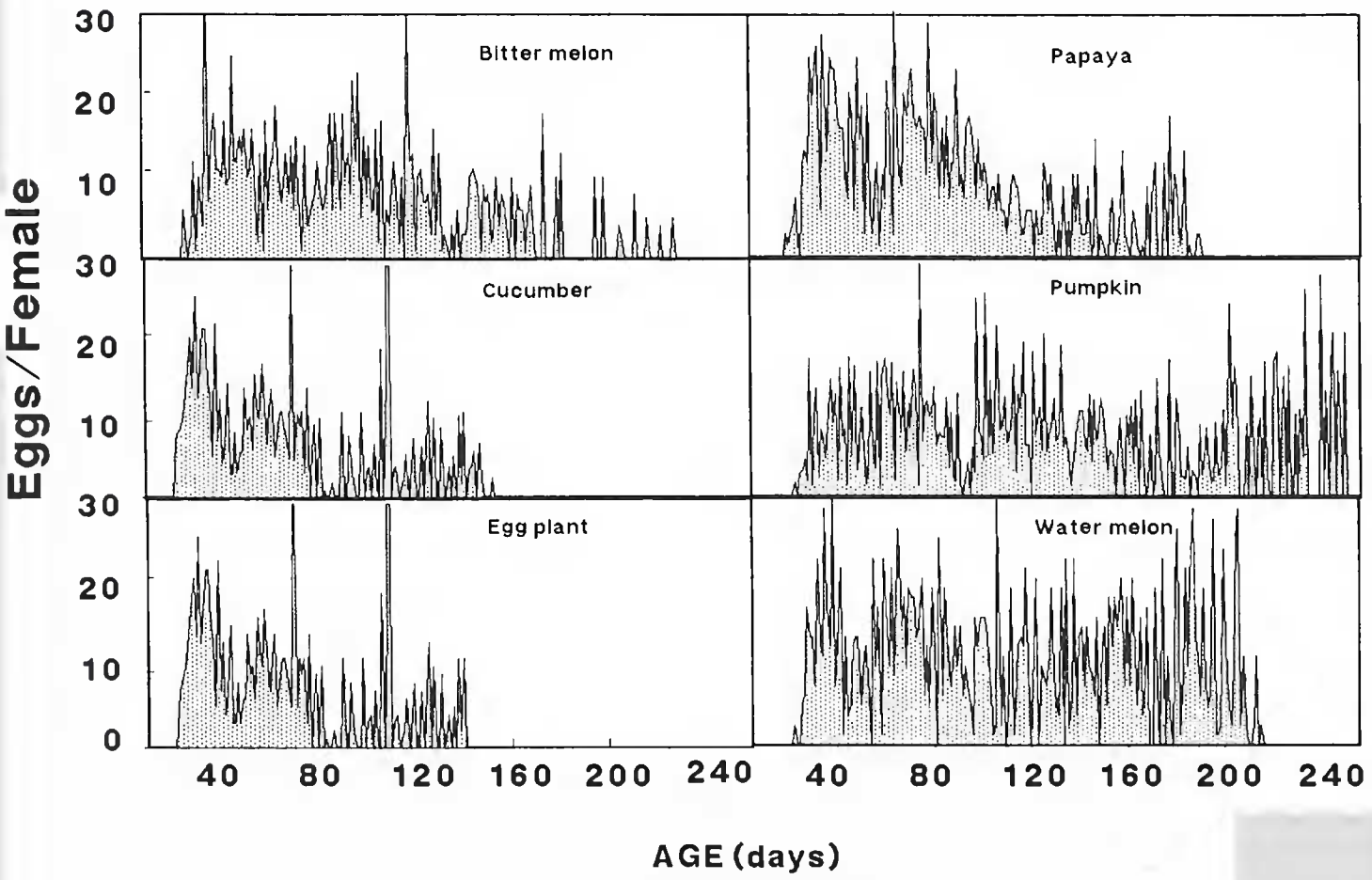

Figure 1. Number of eggs per female/day for *B. tau* reared on six hosts.

the sand was sifted daily to remove pupae. Fifty pupae were placed in a Petri dish in a 1 liter glass jar and adult emergence was recorded daily.

Fifty pairs of newly emerged adults were placed in a cubical cage (25 cm per side) provisioned with water and a 3:1 volumetric mixture of commercial sugar and enzymatic yeast hydrolysate. A thin slice of pumpkin was placed in the cage daily to determine egg production. Mortality was recorded daily until all adults had died. All tests were conducted in a room maintained at 25° ± 0.5° C, 50–75% RH, and 12:12 L:D. The demographic parameters were calculated and summarized according to Carey (1993).

Results

Duration and survival of *B. tau* eggs were independent of host and averaged approximately 1.5 days and 87% respectively. Larval developmental time ranged from 4.5 days, for flies reared on cucumber, to 7.3 days, on eggplant. Larval survival rates ranged from 48%, on bitter melon, to 77% on cucumber. There are no significant differences among pupal developmental times or survival rates among the different hosts ($P > 0.05$; Analysis of Variance) (Table 1).

Expectation of life of adult females ranged from 52 days, for flies reared on eggplant, to 109 days, for those reared on bitter melon. Gross fecundity rate ranged from 886 eggs/female, for flies reared on eggplant, to 1700 eggs/female, for those reared on watermelon (Table 2).

The reproduction patterns of females reared on the six hosts were similar (Fig. 1). Age at first reproduction was approximately 16 days, and peak egg laying occurred shortly after this. Females reared on bittermelon, cucumber, eggplant, and papaya had egg production that peaked early in life (40–80 days) and declined

Table 3. Life table parameters of *Bactrocera tau* reared on six common hosts as computed from laboratory birth and death rates.

Host	Parameter[a]						
	b	d	r	λ	R_o	T	DT
Bitter melon	0.159	0.063	0.096	1.100	184	54.4	7.2
Cucumber	0.125	0.004	0.123	1.104	180	42.3	5.6
Eggplant	0.155	0.043	0.112	1.118	95	40.7	6.2
Papaya	0.128	0.027	0.099	1.104	183	52.3	7.0
Pumpkin	0.132	0.032	0.092	1.097	169	59.1	7.5
Watermelon	0.120	0.033	0.087	1.091	138	56.8	8.0

[a] b = intrinsic birth rate; d = intrinsic death rate; r = intrinsic rate of increase (daily); λ = finite rate of increase (daily); R_o = net reproductive rate; T = mean generation time (days); DT = population doubling time (days).

thereafter. Flies reared on pumpkin and watermelon layed eggs over a longer time span and lacked a clear decline in egg production. Average daily egg production ranged from 5.8 to 7.5 days (Table 2). There was a small number of highly fecund and longer-lived individuals in every cohort, especially among those reared on pumpkin and watermelon (Fig. 1).

Demographic parameters of *B. tau* reared on six different hosts were calculated from the development and survival information for preadults and the life history information for adults (Table 3). Flies reared on eggplant had the lowest net reproductive rate. Flies reared on bitter melon, papaya, and cucumber had similar net fecundity rates that were twice that of flies reared on eggplant. Generation times ranged from 40.7 to 59.1 days. Intrinsic rates of increase ranged from 0.087, for flies reared on watermelon, to 0.123, for those reared on cucumber. The stable age structure of *B. tau* populations reared on different hosts are shown in Table 4. The fraction of flies in each stage was similar among the different hosts except for eggplant. The greater proportion of the population in the larval stage, and smaller proportion in the adult stages, reflect reduced larval survival and increased larval development times in eggplant (Table 1). It takes more *B. latifrons* larvae in eggplant to give rise to each adult compared to the other host plants.

Discussion

Our results are similar to those obtained for *B. tau* reared at 25° C on cucumber (Zhou et al. in press) for larval (4.5 versus 6.1 d) and pupal (9.6 versus 10.0 d) developmental times. Rates of gross and net fecundity (979 versus 911 eggs, and 665 versus 538 eggs respectively) were greater in Zhou et al., but our daily egg

Table 4. Stable age distribution (percent) for *B. tau* reared on six different hosts.

Stage	Bitter melon	Cucumber	Eggplant	Papaya	Pumpkin	Watermelon
Egg	22.1	20.0	21.9	17.9	18.7	17.2
Larva	38.6	37.0	51.1	38.4	42.5	39.9
Pupa	23.7	30.0	18.0	26.2	22.5	26.3
Adult	15.6	13.0	9.0	17.5	16.3	16.6

deposition rate was greater (7.5 versus 6.0 eggs per day). The intrinsic rate of increase (0.11 versus 0.12) and finite rates of increase (1.11 versus 1.10) were almost identical.

Similar rates of population increase (represented by the finite rate of increase) for *B. tau* reared on six different hosts indicate that these hosts had similar overall effects on *B. tau* populations. Although flies reared on eggplant have the lowest fecundity and the shortest life expectancy, they have the highest finite rate of increase because their short generation time offsets lower egg production. Similar life history traits have been found in *C. capitata* (Carey 1984, Krainacker et al. 1987). *B. cucurbitae* (Carey et al. 1985), and *Anastrepha* spp. (Celedonio-Hurtado et al. 1988).

Finite rates of increase of *B. tau* in this study are similar to those of *B cucurbitae* in Hawaii and southern China, where these two species of flies were reared on the same hosts (Carey et al. 1985). For example, the finite rate of increase for *B. cucurbitae* was 1.12 to 1.05 when reared on cucumber in Hawaii and southern China, respectively, but that for *B. tau* was 1.10. Our data agree with the results of other comparisons of *B. tau* and *B. cucurbitae* (Yang 1992). *Bactrocera cucurbitae* is considered an important and potentially dangerous exotic pest to agriculture in California. Our data indicate that *B. tau* is as dangerous a pest as *B. cucurbitae,* based upon their similar host ranges and population growth capacities. *Bactrocera tau* ranges further north into China than *B. cucurbitae* (Yang 1992) and, thus, poses a greater threat in California, especially in those areas that are marginally available to *B. cucurbitae,* such as the San Francisco Bay area.

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